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ESTABLISHMENT OF *LARINUS MINUTUS* GYLLENHAL (COLEOPTERA: CURCULIONIDAE) FOR BIOLOGICAL CONTROL OF DIFFUSE AND SPOTTED KNAPWEED IN THE WESTERN UNITED STATES

R. F. LANG,[1] J. M. STORY,[2] AND G. L. PIPER[3]

[1]United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine,
Forestry Sciences Laboratory, Montana State University,
Bozeman, Montana 59717;
[2]Western Agricultural Research Center, Montana State University,
580 Quast Lane, Corvallis, Montana 59828;
[3]Department of Entomology, Washington State University,
Pullman, Washington 99164

Abstract.—*Larinus minutus* Gyllenhal (Coleoptera: Curculionidae) is a capitulum-infesting natural enemy of diffuse and spotted knapweed (*Centaurea diffusa* Lamarck and *C. maculosa* Lamarck) (Asteraceae). United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine personnel and research collaborators released 13,791 adults from 1991 to 1993 for the biological control of these knapweeds. Weevil establishment was confirmed in Montana in 1992, and in Washington and Wyoming in 1993. Redistribution began in 1994 from one site each in Montana, Washington, and Wyoming. As of 1994, *L. minutus* had also been released in Minnesota, Nebraska, Oregon, and Utah for a total of seven states and 24 counties.

Key Words.—Insecta, biological control, weed, *Larinus, Centaurea*

Diffuse and spotted knapweeds (*Centaurea diffusa* Lamarck and *C. maculosa* Lamarck) (Asteraceae) are European plants accidentally introduced into North America that have become serious weeds of rangelands, pastures, and waste areas. Spotted knapweed, initially reported from Montana in 1927, now infests 1,912,181 ha in the state (Roché 1994b). In 1984, the estimated loss of forage in Montana attributable to *C. maculosa* was $4.5 million (French & Lacey 1983). Washington, in 1993, was estimated to have 851,700 ha of diffuse and spotted knapweed-infested rangeland (Roché 1994a). Knapweeds are aggressive, invasive competitors that rapidly displace desirable forage grasses and forbs, including native plants. Diffuse knapweed is a biennial and spotted knapweed is a short-lived perennial, and both species reproduce exclusively by seed. In order to reduce seed production and spread, various European capitulum-feeding insects have been introduced into North America for the classical biological control of these *Centaurea* spp. (Piper & Rosenthal 1995, Story 1995). These insects include *Metzneria paucipunctella* Zeller (Lepidoptera: Gelechiidae), *Chaetorellia acrolophi* White and Marquardt, *Terellia virens* Loew, *Urophora affinis* (Frauenfeld), *U. quadrifasciata* (Meigen) (Diptera: Tephritidae), *Bangasternus fausti* (Reitter), *Larinus obtusus* Gyllenhal, and *L. minutus* Gyllenhal (Coleoptera: Curculionidae).

Larinus minutus feeds only on diffuse and spotted knapweed. Overwintered adults begin emerging in mid-May and feed upon stems, foliage, flower buds, and flowers (Groppe 1990). Females deposit eggs among the florets of opened capitula. Upon hatching, larvae feed within the capitula upon the developing seeds.

Table 1. *Larinus minutus* releases, recoveries and establishments, 1991–1993.

State	County	Year(s) released	No. released	No. recovered	Establishment
Montana	Gallatin	1991–1993	1693	4	Yes
	Lewis & Clark	1991–1992	2592	55	Yes
	Park	1992	217	0	No
	Powell	1991	50	0	No
	Sweet Grass	1992–1993	1572	6	Yes
Nebraska	Holt	1992	200	0	Destroyed
Oregon	Deschutes	1992	200	—	Yes
	Hood River	1992	200	—	Yes
Washington	Spokane	1991–1993	1045	210	Yes
	Stevens	1991–1993	406	44	Yes
	Whitman	1992–1993	400	180	Yes
Wyoming	Natrona	1991	175	4	Yes
	Teton	1992	1500	—	Yes

—, Not recorded.

One larva can destroy all the seeds in a diffuse knapweed capitulum; one or more larvae reduce seed production by 25 to 100% in the larger capitula of spotted knapweed. Pupation occurs within the damaged capitula (Groppe 1990). Adults emerge during late summer and feed upon the foliage of knapweed rosettes for a short period of time before seeking overwintering sites in the soil or debris in the vicinity of their host plants. The weevil has one generation per year. This paper documents the establishment and redistribution of *L. minutus* in the western United States.

Materials and Methods

Larinus minutus was approved for release in the United States on 26 June 1991 by the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection and Quarantine (PPQ). Adult weevils were collected in Europe (Greece and Romania) by personnel from the Commonwealth Agricultural Bureaux International Institute of Biological Control, Delémont, Switzerland. The beetles were received and held in quarantine at the USDA-APHIS-PPQ Mission Biological Control Laboratory, Mission, Texas, prior to field release.

Uncaged releases of *L. minutus* adults on diffuse and spotted knapweed were made by cooperators in Montana, Nebraska, Oregon, Washington, and Wyoming between 1991 and 1993 (Table 1).

To document establishment, sites were sampled the year following release. Assessments were conducted in early May, late June, or early July, and September through October. The undersides of rosette leaves were examined for feeding adults in early May. The adults were found feeding on the leaves and flower buds of bolted plants in late June and early July. If no adults were observed during the summer months, sweep samples were taken by walking in an expanding circle from the release point to approximately 6 m out from the center. Visual and sweep sampling were undertaken during mid-morning (1000 h) and late afternoon (1400 h) on warm, sunny days. The knapweed stands were also checked for the occur-

rence of adult emergence holes in late September through October as another method to confirm establishment. The large emergence holes, positioned in the centers of mature capitula, can readily be seen while walking through a knapweed infestation.

Weevil establishment was considered to be achieved when adults were recovered the year after the initial release. Collection of *L. minutus* adults for redistribution from field insectary sites occurred when it was determined that 25% of the capitula within 30 m of the release point contained emergence holes.

Results and Discussion

In 1992, *L. minutus* larvae or adults from the 1991 releases were recovered from two sites in Montana: East Gate in Lewis & Clark County (24 Jul, $n = 11$) and Droulliard Fishing Access in Gallatin County (12 Aug, $n = 4$) (Table 1). No other recoveries were reported from the 1991 releases. By 1994, Montana had five established *L. minutus* field insectaries. In 1994, the East Gate release location provided 2685 adults which were released in Montana [Gallatin ($n = 1166$) and Sweet Grass ($n = 84$) County], Minnesota (Becker County) ($n = 400$), and Nebraska (Pierce County) ($n = 1035$). In 1993, Washington reported recoveries of the weevil in three of four counties and from all four counties in 1994. Washington redistributed 4195 adults from Whitman County in 1994 to Columbia, Franklin, Grant, Okanogan, Stevens, Walla Walla, and Whitman Counties. Wyoming recovered *L. minutus* adults in 1993, and in 1994 was able to redistribute 562 adults from Natrona County to two other sites within the county. Oregon reported recovery from Deschutes and Hood River Counties in 1994. The Nebraska (Holt County) 1992 release site was destroyed in 1994, with no weevil recovery being recorded (Table 1). A release of 375 *L. minutus* from Greece was made in Utah (Weber County) in 1994.

Larinus minutus is well-established in Oregon, Montana, Washington, and Wyoming (Table 1). The Montana weevil populations increased rapidly despite an unseasonably cold summer in 1993. By summer's end in 1994, this beetle had been released in 24 counties in seven states, with release material originating from both European and domestic sources. It appears that collections from most field insectaries will be possible within three years of the initial establishment. Populations of *L. minutus* now established in Oregon, Montana, Washington, and Wyoming should continue to expand and provide additional weevils for redistribution purposes in these and other western states with diffuse and spotted knapweed infestations.

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